WYE CITY GROUP MEETING ON *RURAL DEVELOPMENT AND AGRICULTURE HOUSEHOLD INCOME*
Session 2: Innovation, new tools and results in rural statistics - Rome, 11-12 June 2009

SIMULATION OF THE EFFECTS OF CLIMATE CHANGE ON BARLEY YIELDS IN RURAL ITALY

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INTRODUCTION

- **Climate changes** can effect crop yields considerably, leading to significant economic and **socio-political repercussions** worldwide.

- One of the main contributing factors to climate change is the **greenhouse effect** which causes changes in temperature in the atmosphere and in rainfall, both in terms of precipitation levels and its distribution.

- It is the **task of research** to provide specific adaptation strategies in response to possible climate changes in an attempt to protect soil fertility and to guarantee adequate agricultural production – both in terms of quantity and quality, coupled with economic sustainability.

- Crop growth and development **simulation models** are a valuable cognitive tool in understanding water and nutrient dynamics in soil/plant systems.

- **Cereal production** is considered to be particularly important in satisfying world food demand. Despite genetic improvements and the use of fertilizers and pesticides, cereal production is still closely linked to **climate conditions**, due to the fact it is grown in open fields over vast areas and, in many cases, without irrigation.

- Specific research, therefore, is needed in order **to evaluate the effects of climate change on cereal production**. This work focuses on possible variations in barley production as a result of climate change, based on variations in temperature and rainfall.

- The **study** was carried out in **four large areas in Italy** which can be considered representative of the many soil-climate conditions found in Italy.

AGRONOMIC ASPECTS OF BARLEY PRODUCTION

- **Barley** is a cereal which is growing in importance worldwide. It is the **4th most cultivated cereal in the world**, following wheat, rice and maize.

- Barley grain is used both for **human consumption** and **animal feed**. It is used in the production of **malt** and in the **drinks industry** for roasting, and the plant can also be used as a fodder crop when **harvested green**.

- **Good genetic variability** gives it outstanding **adaptability** to climate and location. Its ability to thrive in **adverse conditions**, as shown in studies carried out by a number of scientists, leads to **lower production costs** and a reduced use of synthetic pesticides compared to durum wheat.

- This is a good indication of the **crop's potential**, especially as a **sustainable**, **environmentally friendly crop**.

- Studies carried out by various research centres throughout the country have shown that, of the two-rowed barley types, **some varieties** showed **high adaptability** to soil-climates conditions with **medium-high production levels** and **good grain quality**.

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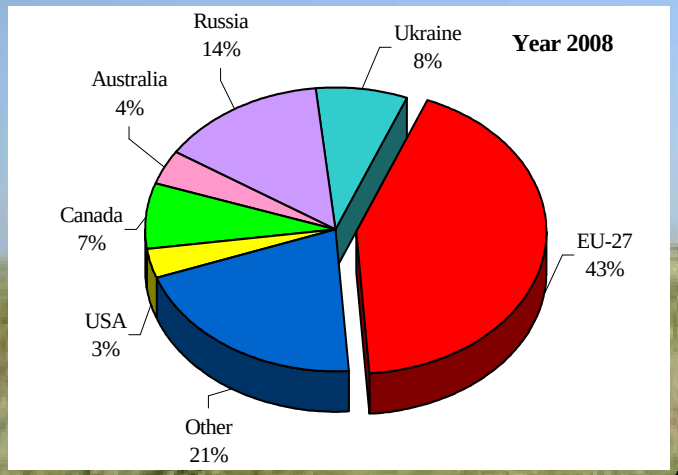
ECONOMIC ASPECTS OF BARLEY PRODUCTION

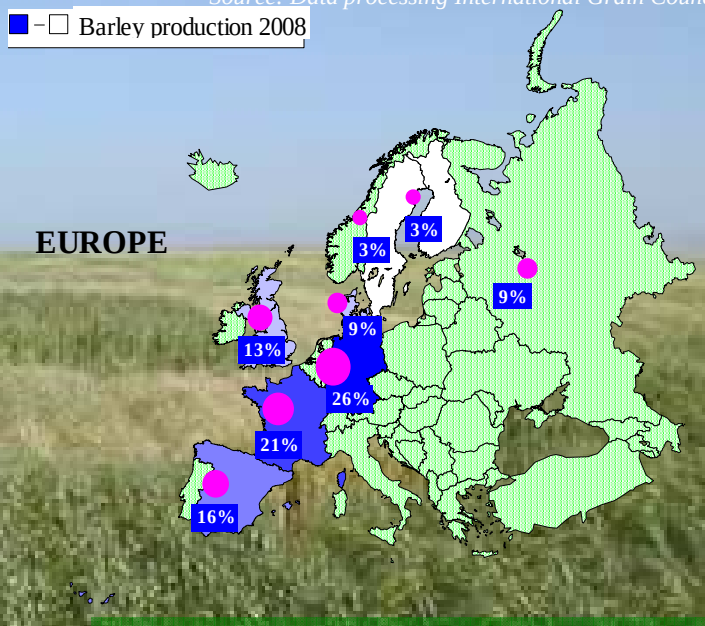
World barley production (%)

Source: Data processing Toepfer, International, USDA, Canada, ABARE



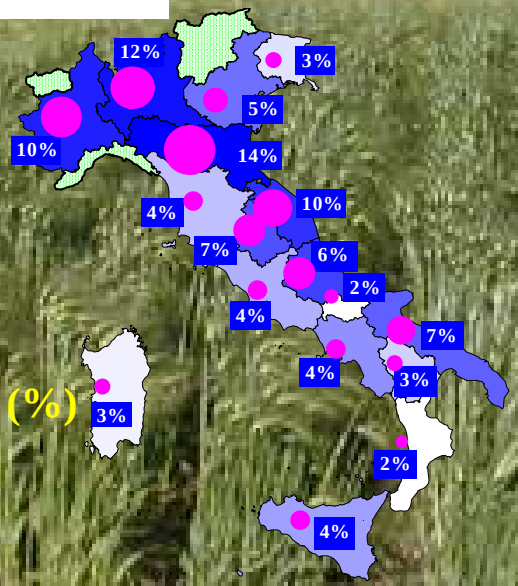
Barley production in Europe (%)

Source: Data processing International Grain Council



Barley production in Italy (%)

Source: Data processing ISTAT



- **World barley production** estimates for 2008 = *153 million tonnes*, up 15% on figures for 2007.
- Europe, with its 27 nations, is the largest world producer of barley at 66 million tonnes (43% of the world's total).
- In Italy, overall production in 2008 was 1,240,000 tonnes.
- North Italy produces 45% of the country's total, confirmation that the areas of Lombardy and Emilia Romagna are highly suited to barley production

SIMULATION OF BARLEY PRODUCTION IN 4 SELECTED RURAL AREAS OF ITALY

➢ The following papers aims to examine the **direct and indirect effects** of climate change on barley **yields**.

➢The two-rowed cultivar **Baraka** was favoured as it is widely cultivated and produces good quality yields throughout Italy and a good deal of experimental data on this cultivar was available.

➢ The **CERES model** was used to simulate barley growth and development coupled with climate change scenarios taken from the regional climate model (RegCM) **MM4** developed by **NCAR** (National Center for Atmospheric Research, Boulder, Colorado, USA).

➢The **first stage** of the study involved the **calibration** and **validation** of the **CERES model** using experimental agronomic data (**base-line**) taken from areas belonging to the national network of the Experimental Institute for Cereal Cultivation, each from the **4 macro land areas** in Italy:

1) S. Angelo Lodigiano (MI) for the North of Italy;
2) Jesi (AN) for Central Italy;
3) Foggia (FG) for the South of Italy;
4) Cammarata (AG) for the Islands.

Physical-chemical characteristics of selected study areas

Land Analysis	S. Angelo Lodigiano (MI)	Jesi (AN)	Foggia	Cammarata (AG)
Altitude (m)	70	42	0	460
nature of land	flat	flat	flat	gently sloping
Sand (%)	52,3	18	25,1	36
Silt (%)	38	46	21,5	29
Clay (%)	9,7	36	53,4	35
Total limestone (%)	0	28,7	2,5	24
Organic matter(‰)	0,91	1,97	1,65	0,17
Total nitrogen (‰)	1,72	1,13	0,13	0,9
Soil-available Phosphorus (ppm)	82,7	31	51	6,1
Soil-availablePotassium (ppm)	95,7	238	715	78,3
pH	7,6	7,2	7,4	7,3

SIMULATION OF BARLEY PRODUCTION IN 4 SELECTED RURAL AREAS OF ITALY

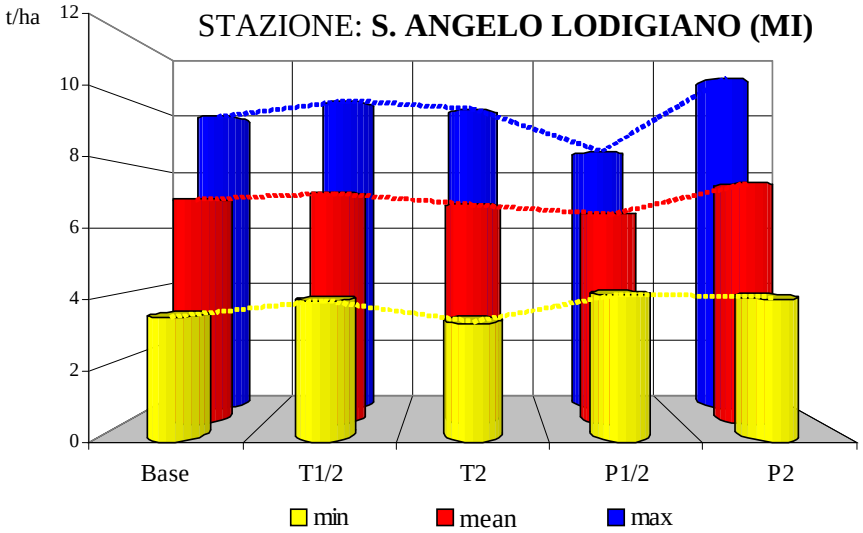
- The **calibrated** and **validated** model was used to evaluate the **effects of climate change** on barley **yields** and to analyse the interannual variability of productions.
- The simulations were carried out on **99 years** taking into consideration the soil type and cultivation techniques found at the stations under study.
- In order to analyse vulnerability to climatic variability for each station, **5 weather sets** of 100 years were generated.
- The **5 weather** sets were generated with a constant mean for the observed data (**Base**) and by varying the temperature data (**T**) and the precipitation (**P**) by a factor of ½ and 2, considering CO2 concentrations of 330 ppm. The resulting sets were:

  - **Base** (constant mean of observed data and constant variability of observed data)
  - **P ½** (constant mean of observed data, variability of the temperature equal to that observed and variability of precipitation halved);
  - **P2** (constant mean of observed data, variability of the temperature equal to that observed and variability of precipitation doubled);
  - **T ½** (constant mean of observed data, variability of the temperature halved and variability of precipitation equal to that observed);
  - **T2** (constant mean of observed data, variability of the temperature doubled and variability of precipitation equal to that observed).

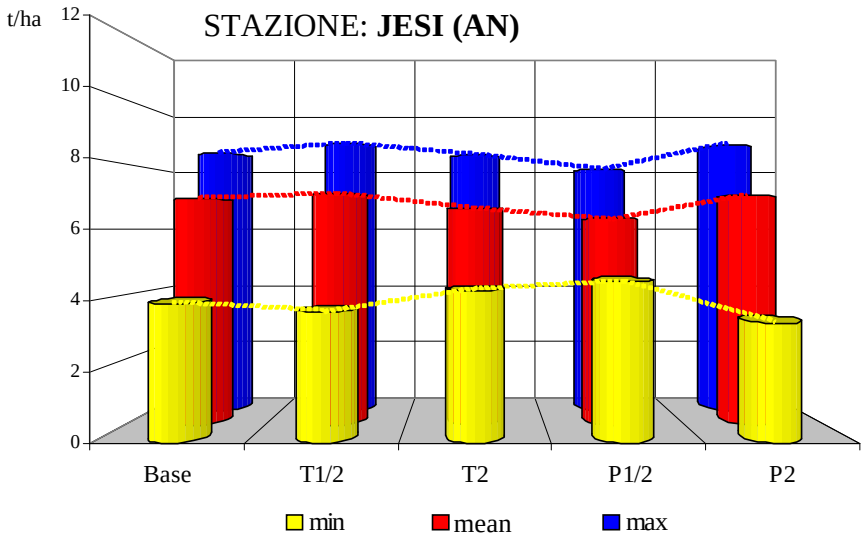
The "**physical**" meaning of the scenarios consists in the **differing probability**, compared to the observed data, of the occurrence of temperature and rainfall extremes, and in the increased variability of the same size scenarios occurring on a daily basis.

Results: Effects of climate change in the selected study areas

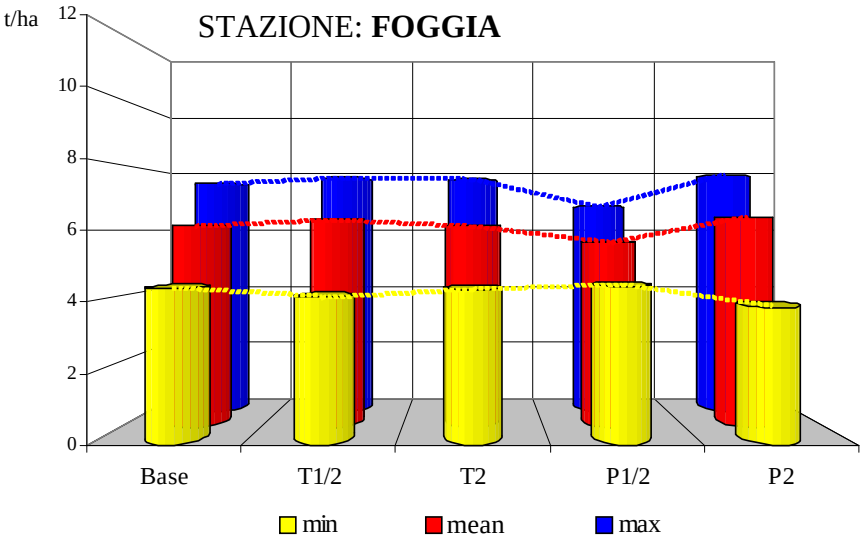
CULTIVAR: **BARAKA**
AREA: **NORTH**
STAZIONE: **S. ANGELO LODIGIANO (MI)**



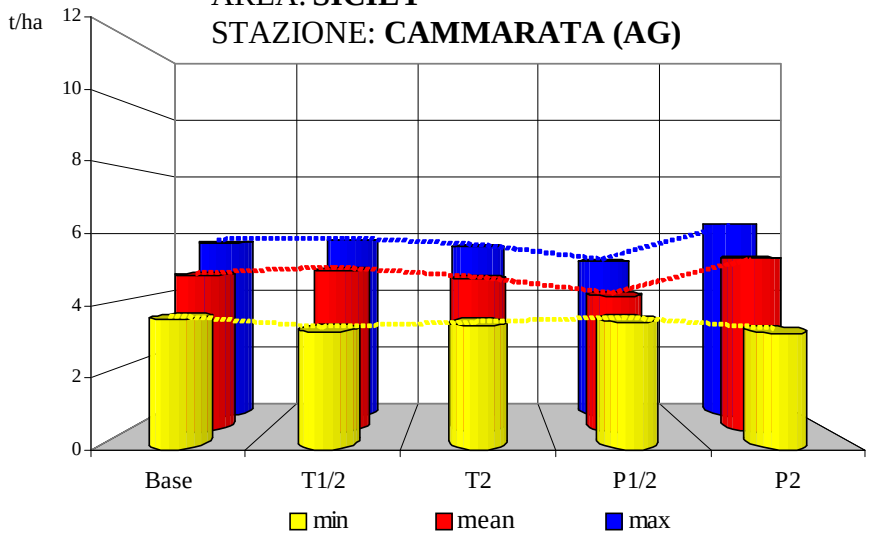
CULTIVAR: **BARAKA**
AREA:**CENTRAL**
STAZIONE: **JESI (AN)**



CULTIVAR: **BARAKA**
AREA:**SOUTH**
STAZIONE: **FOGGIA**



CULTIVAR: **BARAKA**
AREA: **SICILY**
STAZIONE: **CAMMARATA (AG)**



SIMULATION OF BARLEY PRODUCTION IN 4 SELECTED RURAL AREAS OF ITALY

RESULTS

- Statistical elaboration highlights the **absence** of any appreciable **differences** in the precipitation and temperatures scenarios compared to the Base.

- Only the **S. Angelo Lodigiano (MI) station** showed a **difference in yield** (minimum and maximum) of less than 18% for the various scenarios generated with differing temperature and rainfall conditions.

- In the stations in the **South of Italy**, and, in particular in **Sicily**, the **gap** between the maximum and minimum yields is **smaller**, with the response to differing temperature and rainfall conditions remaining fairly **stable**.

- **Maximum barley yields** from the four stations ranged from **5-6 t/ha** (Cammarata Station in Sicily) to **10-11 t/ha** (S. Angelo Lodigiano Station in the North of Italy).

- The **minimum yields** showed satisfying levels (**3-4 t/ha**) for all the stations and the weather scenarios studied with limited variations.

CONCLUSIONS

- The study of climate change using the CERES model has highlighted its possible application in the **primary sector** by carrying out a series of simulations connected to probable future climate conditions and the production response of **crops in rural areas** of the country.

- Results show that **yield** variability **increases slightly with** a rise in the variability of both the **temperature** and **rainfall** levels. These effects are **greatest** in the **North of Italy** and they **diminish** in the **South of Italy** and **Island** areas.

- Analysis of the vulnerability of the cultivar Baraka to climate variability highlighted a greater **yield sensitivity** to **rainfall** compared to that of temperatures.

- The implementation of adequate **monitoring systems**, with advanced data management and the development of models such as that used in this study, is considered crucial for **policy making** in this sector and when deciding strategies for **mitigating effects**.

- The **widespread application** of prediction models is to be encouraged given their **numerous advantages** when choosing agronomic practices which are correct, profitable, **eco-compatible** and long-lasting.